

# **Singapore and the Revolution in Military Affairs**

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Singapore's military capability is, by most measures, the most advanced in Southeast Asia. The build-up of Singapore's armed forces and its national defense industry, as well as local defense R&D, reflects the determination of the People's Action Party (PAP) government to ensure the city-state's survival in a potentially hostile regional environment. However, these developments would not have been possible if Singapore had not possessed such a highly-developed economy and well-educated population. These advantages, reinforced by increasingly intense interaction with the armed forces and defense industries of advanced industrial countries, have allowed Singapore to make substantial strides toward participation in the Revolution in Military Affairs (RMA) since the 1990s. Singapore has fielded increasingly sophisticated defense systems, particularly in the RMA-critical areas of precision weapons, command, control, communications and computer-processing (C4), and intelligence, surveillance and reconnaissance (ISR). Integrated logistic support (ILS) is also well-developed. Though the doctrinal and organisational innovation required to implement the RMA is so far rather less well advanced, Singapore seems to have made substantial progress towards establishing a relatively low cost 'system of systems' which will far outclass the military capabilities of other Southeast Asian states for at least the next decade. And although Singapore's government has become increasingly concerned over asymmetric threats, it is clearly determined to maintain its emphasis on developing high-technology conventional military capabilities.

## **SINGAPORE'S DEFENSE POSTURE**

Geopolitical circumstances have forced Singapore's government to take defense extremely seriously since the city-state separated from Malaysia in acrimonious circumstances in 1965. Though the government sees security holistically and has implemented a strategy known as Total Defence, which provides for the wholesale mobilisation of the population and national resources in time of crisis or conflict, the military component of defense has always loomed large. Despite Singapore's small size and population, by the late 1990s its armed forces were probably the best-equipped, best-trained and potentially most effective in Southeast Asia. The government routinely devotes 25-30% of its total annual spending (roughly 5% of GDP) to the armed forces. In 2001/2, Singapore's defense spending amounts to US\$4.5bn, by far the largest national defense effort in Southeast Asia.<sup>1</sup>

The development of the Singapore Armed Forces (SAF) has traditionally been based on the need to deter and, if deterrence fails, to defend against threats posed by its much larger neighbours to north and south, Malaysia and Indonesia. Secondly, Singapore's

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<sup>1</sup> 'Budget 2001', *Straits Times*, February 23, 2001.

military capability has provided a firm basis for security cooperation with friendly powers from outside the region. Pre-eminent amongst these extra-regional associates is the United States, which developed into a quasi-ally during the 1990s. But Singapore has always based its defense on the potential necessity of defending itself without direct outside help.<sup>2</sup>

In developing their armed forces, Singapore's leaders have increasingly stressed the importance of exploiting technology to compensate for the city-state's lack of strategic depth and shortage of professional military manpower. Though the Singapore Armed Forces (SAF) can mobilise 350,000 personnel if necessary, only 20,000 of these are regulars: the remainder are conscripts and reservists. The SAF prizes its 'technological edge', which has almost certainly provided it with conventional military advantages over any likely adversaries in its immediate region. In part, this technological edge has derived from purchases of advanced military equipment from overseas suppliers (for example, F-16C/D fighter/strike aircraft from the US during the 1990s) but it is also a product of Singapore's highly capable defense industry and defense R&D efforts.

Singapore's defense establishment clearly recognises the RMA's significance. According to *Defending Singapore in the 21<sup>st</sup> Century* (DS21), MINDEF's most recent comprehensive defence policy statement (issued in February 2000):

The revolution in military affairs will change the nature of warfare. Superior numbers in platforms...will become less of an advantage unless all these platforms can be integrated into a unified, flexible and effective fighting system using advanced information technologies. At the same time, the ever-increasing reliance on information technology means that protecting one's own information systems and disrupting the enemy's will become a major aspect of warfare...<sup>3</sup>

Placing the SAF's future development firmly in this new context, DS21 promised that the SAF would 'exploit developments in the RMA, such as the integration of information technology into weapon systems' to achieve battlefield superiority.<sup>4</sup> As for Singapore's defence industry, 'the digital battlefield of the future and the need for commercial technology in IT and communications will influence the approach we take to ensure that we sustain a technological edge'.<sup>5</sup>

## **ECONOMIC AND EDUCATIONAL ADVANTAGES**

In attempting to participate in the RMA, MINDEF and the SAF have been able to exploit important national advantages. Despite occasional setbacks, Singapore has achieved outstanding economic success since the 1960s. Rapid and sustained growth, deriving

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<sup>2</sup> For a fuller assessment of Singapore's defence policy, threat perceptions and strategy, see Tim Huxley, *Defending the Lion City: The Armed Forces of Singapore* (St Leonards, NSW, Australia: Allen & Unwin, 2000), pp. 24-72.

<sup>3</sup> *Defending Singapore in the 21<sup>st</sup> Century* (Singapore: Ministry of Defence, 2000), p. 10.

<sup>4</sup> *Ibid.*, p. 75.

<sup>5</sup> *Ibid.*, p. 69.

largely from the government's relentless efforts to direct the economy into higher value-added, more highly technological and more capital- and knowledge-intensive activities, gave Singapore Asia's highest and the world's fourth highest per capita GDP by 1997. Though Singapore was affected by the region-wide recession that began in 1997, it was not so badly hit as its neighbours: growth recovered from 1.5% in 1998 to 5.4% in 1999 and 10.1% in 2000. In 2001, the weakness of US economic growth, world semiconductor sales and other regional economies caused a collapse in manufacturing exports, causing an economic contraction of 2%. This was the worst recession since independence. However, by early 2002 the economy appeared to be reviving strongly and growth of 3-4% was expected for the year. Over the coming decade, Singapore government economists predict annual growth in the 4-6% range. Economic prosperity has underpinned high levels of defence spending, which have in turn allowed the SAF to benefit increasingly from high-technology equipment, modern infrastructure and high-quality training facilities.

Singapore's sophisticated economy is increasingly based on the types of activity needed to support a local version of the RMA. By 1998, Singapore was ranked as 'the world's fourth most information-driven economy' (after the US, Sweden and Finland).<sup>6</sup> The telecommunications, IT and media industries were by the late 1990s the most important area for new investment in the economy's service sector. The government is pushing the economy increasingly towards R&D and in October 2000 unveiled its National Science and Technology Plan for 2001-5, under which it will invest US\$4bn in high technology R&D with the aim of transforming Singapore into a 'knowledge-based economy' (KBE). A highly-developed information technology (IT) and communications sector will be key to the KBE.<sup>7</sup>

Economic progress has both facilitated and necessitated dramatic advances in Singaporeans' educational achievement. The education system is now explicitly geared towards educating Singaporeans for the KBE. The government's 1997 education blueprint, *Thinking Schools, Learning Nation*, encompasses a key initiative aimed at 'developing critical and creative thinking skills in the young' and a master plan for IT education,<sup>8</sup> the latter aimed at training teachers 'to bring IT into schools to prepare future generations for the digital economy'.<sup>9</sup> To help meet the government's target of increasing Singapore's trained workforce in the IT and communications sector from 100,000 in 2001 to 250,000 by 2010, the Institute of Systems Science aims to train 15,000 students annually by 2005.<sup>10</sup> In the mean time, information and communications technology already plays an prominent part in the lives of most Singaporeans. For example, under the first phase of the 'E-government action plan', 130 key public services are delivered electronically, and are widely used. The government has also established a broadband infrastructure that can be accessed by all schools and more than 99% of homes.<sup>11</sup> Given that the majority of working-age Singaporean men, and many women, are involved in the

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<sup>6</sup> *Singapore 2000* (Singapore: Ministry of Information and the Arts, 2000), pp. 125-6.

<sup>7</sup> Natalie Soh, '\$7b thrust for Science and Tech', *Straits Times Weekly Edition*, October 28, 2000, p. 1.

<sup>8</sup> *Singapore 2000*, p. 215.

<sup>9</sup> 'E-government action plan', *Financial Times* (London), December 6, 2000.

<sup>10</sup> Chang Ai-Lien, 'Boost for infocomms lessons go online', *Straits Times Weekly Edition*, July 7, 2001., p. 1.

<sup>11</sup> 'E-government action plan'.

SAF as regular, reservist or conscript personnel, this trend towards a better-educated population, increasingly familiar with information and communications technology, facilitates the SAF's absorption of the technologically-sophisticated systems intrinsic to the RMA.

## **DEFENSE R&D**

Singapore's strong orientation towards advanced technology is reflected in the vital role played by defence engineers and defence scientists from government agencies and the state-controlled defence industry, as well as 'warfighters', in the Integrated Defence Development process which guides the development of the SAF.<sup>12</sup> Though the republic's technological capacity is limited compared with that of larger industrial states, local development and upgrading of defense systems has provided access to military capabilities not available to Singapore through off-the-self purchase in the international market. In recent years MINDEF has increased its R&D budget substantially, from approximately 1% of defence spending in 1990 to 4% in 2000.<sup>13</sup> In real terms, this implied an increase from US\$20m to US\$160m. Working on the principle that 'we cannot do everything ourselves',<sup>14</sup> the republic's defense R&D establishment and industry have made strenuous efforts to acquire relevant technology through collaboration with both international and local partners. Crucially, Singapore's defense decision-makers realise that leads in military technology are ephemeral, and that defense R&D is a constant race to stay 'ahead of the game'.<sup>15</sup>

MINDEF claims that local R&D has provided the SAF with 'silver bullets' - advanced systems that might prove militarily decisive in 'extreme conditions'.<sup>16</sup> But the essence of Singapore's RMA-relevant defense technology effort focuses on acquiring, developing and integrating information and communications technologies for command and control with ISR systems and precision-guided weapons. The aim is to allow SAF combat units to locate, target and destroy targets more effectively in the context of round-the-clock combined arms and joint-service operations. Developing and refining such a capability will be key to the SAF's continuing regional military superiority in the early twenty-first century.

The three 'key pillars' underpinning Singapore's ability to harness technology for defense purposes, according to Deputy Prime Minister and Minister for Defence Tony Tan, are the SAF's highly-educated personnel, a 'versatile' local defense industry, and the Defence

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<sup>12</sup> Keynote address by Dr Tony Tan, Deputy Prime Minister and Minister for Defence, at the Signing Ceremony of the Statement of Intent for the Temasek Defence Systems Institute, Singapore Government Press Release, July 11, 2001.

<sup>13</sup> Keynote address by Dr Tony Tan at the launch of Temasek Laboratories, MINDEF Internet Webservice, September 6, 2000.

<sup>14</sup> Keynote address by Dr Tony Tan at the signing of the statement of intent for the Temasek Defence Systems Institute, MINDEF Internet Webservice, July 11, 2001.

<sup>15</sup> Speech by Deputy Prime Minister Brigadier-General (NS) Lee Hsien Loong, MINDEF Internet Webservice, October 3, 1997.

<sup>16</sup> Speech by David Lim, Minister of State for Defence and information, MINDEF Internet Webservice, October 29, 1999.

Science and Technology Agency (DSTA).<sup>17</sup> DSTA, a statutory body with a staff of 2400 was established in April 2000 as the outcome of a major restructuring within MINDEF aimed principally at strengthening 'technology acquisition and management'.<sup>18</sup> The Agency is responsible for procuring equipment and services for the armed forces, for developing their infrastructure, and for managing defence R&D. DSTA's directorates of Air, Land and Navy Materiel manage major equipment procurement; its Defence Information Systems directorate handles C4I programs.<sup>19</sup> DSTA collaborates extensively with local and foreign industry on:

- systems engineering and systems integration for new equipment;
- upgrading the performance and capability of existing systems;
- providing engineering support for selected weapon systems; and
- keeping abreast of relevant technology and advising the SAF on how to exploit it.

In addition, DSTA - through its CSO Development Laboratory - is the design authority for all MINDEF and SAF C4I systems' hardware and software, as well as for simulation systems, employing more than 400 engineers in divisions specialising in advanced technology, mission planning and wargaming, air, land, naval, joint, communications, and dual-use (civil-military) systems. DSTA engineers' work on C4I uses 'battle lab' modelling and computer simulations to produce 'customised solutions' for Singapore's requirements.<sup>20</sup> The extremely active 'dual-use solutions' branch has spearheaded the application of commercial-off-the-shelf (COTS) hardware and software within MINDEF and the SAF.<sup>21</sup> DSTA takes exploitation of dual-use technology seriously to the extent of funding small 'start-up' companies conducting research relevant to SAF requirements. For example, with a view to improving battle simulation, DSTA might fund companies creating computer game software.<sup>22</sup>

Fundamental defense R&D are mainly the responsibility of the Defence Science Organisation (DSO) which, with more than 600 engineers and scientists, is Singapore's largest R&D organisation. DSO was originally concerned particularly with electronic warfare, but its capabilities expanded considerably during the 1980s and '90s.<sup>23</sup> In 1997 DSO was corporatised, becoming DSO National Laboratories, a non-profit company affiliated with DSTA. This move was intended to improve DSO's efficiency by introducing more flexible, less bureaucratic commercial best practice in project management, sub-contracting, technological alliances, intellectual property protection and commercial ventures. In the personnel sphere, the intention was to equip DSO better to attract and retain the scientists and engineers who constitute its life-blood.<sup>24</sup>

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<sup>17</sup> Speech by Dr Tony Tan at the launch of the Defence Science and Technology Agency, MINDEF Internet Webservice, March 29, 2000.

<sup>18</sup> Keynote address by Dr Tony Tan at the launch of Temasek Laboratories, MINDEF Internet Webservice, September 6, 2000.

<sup>19</sup> For a description of Singapore's defense procurement process, see Huxley, pp. 175-7.

<sup>20</sup> David Boey, 'Singapore's new drones make public debut', *Business Times* (Singapore), February 26, 2002.

<sup>21</sup> Prasun K. Sengupta, 'Investments in defence R&D pay off', *Asian Defence Journal*, July 1999, p. 26.

<sup>22</sup> Chan Kay Min, 'Defence agency to fund start-ups', *Straits Times*, February 14, 2002.

<sup>23</sup> 'Defence Science Organisation. Defence R&D at its best', *Pioneer*, November 1989, p. 18; Speech by Deputy Prime Minister Brigadier-General (NS) Lee Hsien Loong, MINDEF Internet Webservice, October 3, 1997.

<sup>24</sup> Ibid.

In practical terms, limited resources dictate that while attempting to ‘stay close to the leading edge in the basic technologies’,<sup>25</sup> Singapore’s defense R&D must target highly specific technological niches, chosen in close consultation with the SAF. These niches must offer substantial potential payoffs in terms of enhanced operational capability, lie within DSO’s capabilities and be assessed as worthwhile to investigate ‘in-house’ for reasons of secrecy or because of the lack of alternative sources of the technology in question. DSO conducts R&D through 13 ‘centres of excellence’ that work on areas of particular interest to MINDEF and the SAF. Those of particular relevance to the RMA include:<sup>26</sup>

- Advanced electronics and signal processing
- Decision support
- Information systems security
- Advanced systems (meaning guided systems)
- Communication systems
- Electronic warfare systems
- Radar systems
- Systems engineering
- Unmanned systems

DSO’s work on systems integration and software development has contributed importantly to supporting the SAF’s RMA aspirations. Examples include the integration of radars, various types of surface-to-air missiles (SAM) and fighter aircraft with command and control elements into the air defence system during the 1980s, and the integration and capability optimisation of new sensors and weapons (such as Harpoon anti-ship missiles and Barak SAM) for warships. R&D related to electronic warfare - which MINDEF has specifically identified as a ‘silver bullet’<sup>27</sup> - and to signals intelligence systems and information warfare are also key to the development of RMA capabilities.

DSO has played a central role in exploiting as well as generating ‘dual-use’ technologies. In 1992, it inaugurated a 'Technology Watch' programme with the aim of identifying and monitoring ‘key emerging technologies for application in the SAF’, including ‘ideas from technologically-advanced commercial sectors’. DSO's corporatisation in 1997 has facilitated cross-fertilisation of R&D with local academic and research institutes, notably the National University of Singapore (NUS), Nanyang Technological University (NTU), the Institutes of Systems Science, Information Technology and High Performance Computing, as well as local companies,, helping to expand further its exploitation of dual-use R&D.<sup>28</sup> Dual-use communications technology has been used in components and subsystems for radar systems, and COTS components in the DSO-developed Airborne Compute Engine, an ultra-fast military computer. Dual-use technologies have also played

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<sup>25</sup> Speech by Dr Tony Tan, MINDEF Internet Webservice, November 4, 1998.

<sup>26</sup> DSO National Laboratories website: [www.dso.org.sg/](http://www.dso.org.sg/)

<sup>27</sup> *Defending Singapore in the 21<sup>st</sup> century*, p. 63.

<sup>28</sup> DSO National Laboratories website, [www.dso.org.sg/tech-collaboration.html](http://www.dso.org.sg/tech-collaboration.html) [sic]

a key part in DSO's efforts to develop protection for the military communications and computing infrastructure against information attack'.<sup>29</sup>

Though DSO's focus remains on defence-related R&D on behalf of MINDEF and SAF, it 'can no longer be assumed that defence R&D work will automatically be contracted to DSO'.<sup>30</sup> When DSO was corporatised, MINDEF also established the Directorate of Research and Development (now part of DSTA) as its R&D 'master planner' and buyer of R&D services for the ministry and the SAF - with the option on drawing on sources outside DSO.<sup>31</sup> A potentially important new defence R&D source was established in September 2000 in the form of Temasek Laboratories, a collaborative research venture between DSTA and NUS, specialising in electromagnetics and aeronautics.<sup>32</sup>

DSTA and DSO have drawn extensively on foreign technological expertise in their R&D work, and are increasingly deeply involved in collaborative projects in areas of mutual interest with foreign counterparts, with the aim of maintaining the SAF's technological lead. Much of this cooperation is highly-classified. This applies particularly to Singapore's defense R&D cooperation with Israel, but it is known that this has included work on electro-optics, training simulation, electronic warfare, anti-tank missiles and unmanned aerial vehicles (UAVs).

During the 1990s, Singapore intensified its R&D collaboration with national defense science establishments in several other countries. Despite Washington's concerns during the 1980s that Singapore was a potentially untrustworthy end-user for high-technology military and dual-use exports,<sup>33</sup> US-Singapore defence-technological cooperation has gathered pace in the new context of an increasingly close overall bilateral security relationship since the early 1990s. In 1999, Singapore joined the 'demonstration phase' of the US-UK Joint Strike Fighter (JSF) programme as a 'Level 3 participant', allowing access to information regarding the programme's technological progress.<sup>34</sup> Though this status will not allow Singapore to influence the JSF's design, and no decision has yet been made on continuing participation into the development phase,<sup>35</sup> it might lead to substantial industrial cooperation and an order for the aircraft for Singapore's air force.

Collaboration with Sweden's Defence Research Establishment has also been particularly close, and in 1997 Singapore and Sweden established a Joint Technology Development Fund to finance joint defense R&D projects.<sup>36</sup> Singapore has also explored possibilities for defense-technological collaboration with Australia (a 1993 Agreement for Cooperation in Defence Science and Technology led to joint projects in military

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<sup>29</sup> 'Communication technology – the vital link in warfare', *Pioneer*, March 1999, p. 13; 'Corporatisation of DSO', Media Releases, MINDEF Internet Webservice, March 14, 1997; *Defending Singapore in the 21<sup>st</sup> century*, pp. 66-7.

<sup>30</sup> 'DSO, as a national resource, is uniquely suited to build up technologies for both military and commercial applications', MINDEF Internet Webservice, October 3, 1997.

<sup>31</sup> *The MINDEF/SAF Fact Book* (Singapore: Ministry of Defence, c.1999), p. 21.

<sup>32</sup> 'Technology to sharpen SAF's edge', *Straits Times*, September 7, 2000.

<sup>33</sup> 'US and Singapore in talks to block hi-tech leakages', *Financial Times*, August 16, 1985; 'RSAF plans to update Skyhawks blocked by Pentagon', *Business Times* (Singapore), March 27, 1986.

<sup>34</sup> 'Singapore joins JSF, Australia stays out', *Defense News*, May 10, 1999.

<sup>35</sup> Andrew Doyle, 'Sharper focus', *Flight International*, February 19, 2002, p. 59.

<sup>36</sup> 'Singapore, Sweden set up US\$5m research fund', *Pioneer*, November 1997, p. 10.

communications), France (leading to establishment in 1997 of a Joint Technology Development Fund), South Africa, the United Kingdom and Norway. In 1999, MINDEF set up a Defence Technology Office in Paris to coordinate Singapore's defense technology cooperation with France and other EU members.<sup>37</sup>

## DEFENSE INDUSTRY

DSTA and DSO provide the crucial managerial and R&D underpinnings for Singapore's procurement of RMA-linked defense equipment. However, the role of the local defense industry, which is dominated by government-linked companies belonging to the Singapore Technologies (ST) group, has also been crucial.

Most of the ST companies were first established during the late 1960s and 1970s. Though the early focus was on producing unsophisticated arms and on maintenance, by the 1990s the industry had developed strengths in retrofitting and upgrading (particularly of combat aircraft), and the design, development and production of artillery, armoured vehicles and small and medium-sized naval vessels. With DSTA as an intermediary, the industry has collaborated widely with foreign defense companies, which have facilitated its growing sophistication through Industrial Cooperation Programs involving technology transfer, agreed in connection with contracts for license production and 'off-the-shelf' purchases for the SAF. Singapore's high-technology industrial base, sophisticated and competent defense R&D organisation, and well-educated workforce have enabled it to absorb advanced defence-relevant technologies considerably more easily than other Southeast Asian states. By the end of the 1980s, Singapore's defense industry had become the most substantial, sophisticated and diverse in Southeast Asia.

In 1997, four core ST businesses - ST Aerospace, ST Automotive, ST Shipbuilding & Engineering, and ST Electronic & Engineering - were grouped under ST Engineering (ST Engg), a new publicly-listed company. The aim was to create the critical mass for a listed company which would be more attractive to investors because of its size and smoother revenue stream, and which would benefit from cross-fertilisation and rationalisation of R&D operations. An additional subsidiary, ST Dynamics, was formed soon afterwards to specialise in the development, production and marketing of smart and guided weapons, and unmanned systems, areas that all involve close collaboration with Israeli industry.<sup>38</sup> In early 2000, ST Engg took control of ST's ammunition company, Chartered Industries of Singapore, which was joined with ST Automotive to form ST Kinetics, an integrated land systems arm. ST Engg now deploys a 10,000-strong workforce and the group's sales (60% of which were military) amounted to US\$1.3bn in 2001.<sup>39</sup> The government indirectly still holds more than 56% of the group's shares.

Although ST Engg has to compete against international suppliers, in effect the group remains a favoured supplier to MINDEF and the SAF because of the leeway given during

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<sup>37</sup> 'Dr Tony Tan visits France', MINDEF Internet Webservice, June 12, 1999.

<sup>38</sup> 'Newcomer with a bulging order book', Singapore Survey, *Financial Times* (London), March 31, 1998; Prasun K. Sengupta, "'We have an integrated capability'", *Asian Defence Journal*, July 1999, pp. 22-5.

<sup>39</sup> 'ST Engineering: an emerging world class player in the international defence market', *Military Technology*, 6/2000, pp. 139-40; 'The Focus' (annual report 2001), Singapore Technologies Engineering website, [www.stengg.com/AR2001/index.html](http://www.stengg.com/AR2001/index.html)



the procurement process to opt for local production or upgrading programmes. Senior SAF officers frequently assume positions in ST Engg on leaving active military service, helping to ensure that the local defense industry remains closely attuned to the military's requirements.

ST Engg activities which support the SAF fall into five main categories. At the most basic level, ST Engg continues to provide routine logistic support and depot-level maintenance. This support role expanded during the 1990s as the SAF - motivated by personnel shortages as well as a desire for efficiency gains - commercialised more of its service, support and logistic functions, to local industry's benefit.

ST Engg also continues to supply an extensive range of munitions for all branches of the SAF, and produces or assembles under license a wide range of weapons systems and other equipment, from Russian Igla manportable SAMs to French-designed frigates. In a fourth category of activity, ST Engg companies have - in close collaboration with DSTA and DSO - upgraded the operational capabilities of many SAF weapon systems (such as A-4S strike aircraft, AMX-13 light tanks, and Missile Gun Boats) since the 1980s.

Finally, in conjunction with DSTA and DSO, ST Engg companies have developed and produced a range of new equipment for the SAF. It would be erroneous to call most of these systems 'indigenous', as they have often relied heavily on imported design expertise. Over time, though, the systems produced have become increasingly sophisticated, reflecting local industry's expanding confidence and capabilities. As with the upgrade projects, close collaboration with DSTA and DSO has characterised these programs, which have included the SAR-21 rifle equipped with an integral laser-aiming device and the Bionix infantry fighting vehicle.

Behind the scenes, ST Engg - and particularly ST Electronics - is closely involved with DSTA and DSO in a range of highly-classified C4 and ISR projects, usually only hinted at in official documents. Other key areas of RMA-relevant research involve developing computerised wargaming and simulation, information security systems, and offensive information warfare capabilities.<sup>40</sup>

ST Engg has recently been more open about some aspects of its RMA-relevant R&D. For example, the company has revealed its work on several UAV projects, including the Tailsitter ('smaller than a golf bag') and the Sparrow, a 'palm-sized device'. At the other end of the size range for UAVs, in conjunction with US designer Burt Rutan, ST Engg and DSTA have drawn up plans since 1998 for a huge 'battle management' drone (approximately the size of a Boeing 737 airliner), known as LALEE (Low-Altitude Long Enduring Endurance).<sup>41</sup>

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<sup>40</sup> On information warfare, see Damon Bristow, 'Asia: grasping information warfare?', *Jane's Intelligence Review*, December 2000, p. 36.

<sup>41</sup> Andrew Doyle, 'Singapore recruits Rutan to work on long endurance UAV', *Flight International*, May 15, 2001, p. 5. 'Low-altitude' could be misleading, in that the drone is intended to fly at 60,000 feet - 'low' only in relation to orbiting satellites. 'Long enduring' refers to the platform's expected service life.

At the tactical level, ST Electronics is working on the Futuristic Soldier System (FSS), aimed at improving soldiers' situational awareness, 'hitting power' and 'battlefield survivability', and based on a suite of advanced sighting and aiming devices linked to a backpack computer.<sup>42</sup> In another project looking to the future land battlefield, ST Engg is involved with a US company in developing a system for the US Army's Future Combat System (FCS) requirement using unmanned robotic land warfare systems.<sup>43</sup> Together, these projects promise to revolutionise the technology available to Singapore's army.

## **THE SAF'S RMA-RELEVANT CAPABILITIES**

Along with equipment procured in the international market, the plethora of RMA-relevant projects undertaken by the local defense R&D establishment and local industry have in many cases already fed through into capabilities providing a technological basis for Singapore's participation in the RMA.

### **Advanced weapons systems**

Precision-guided weapon systems and their associated platforms have become ever more prominent elements of the SAF's capabilities over the last decade, increasingly providing the capability to hit targets more accurately and at greater range. Key activities for DSTA ST Engg have been - and continue to be - the integration of guided weapons from diverse sources into the SAF's ships and aircraft and the adaptation and improvement of these missiles' performance. For this reason, access to software source codes is an important consideration for MINDEF when it purchases defense systems in the international market. US restrictions on the transfer of such codes (for example, in connection with the purchase of F-16C/Ds in 1993-4) has sometimes irked Singapore and has undoubtedly stimulated research aimed at overcoming this obstacle. Israel's willingness to supply Singapore with source codes is one reason for its success in marketing defense systems to the city-state.<sup>44</sup>

The navy fields large numbers of US-supplied 90 km-range Harpoon long-range anti-ship missiles on its corvettes and missile gun boats in addition to the earlier, shorter-range Israeli-made Gabriel weapons. By the end of the 1990s, the navy deployed a total of 120 anti-ship missile launchers, the largest number of any Southeast Asian navy. The new French-designed 'modified Lafayette' class frigates, due to become operational from around 2005, will be armed with the latest MM-40 Block II Exocet missiles. Since 1993, the navy has also armed most of its vessels with French Mistral/Simbad air defence missile system. Corvettes are equipped with the Israeli-supplied Barak system, effective against anti-ship missiles as well as aircraft.<sup>45</sup> The Eurosam Aster air defence system is likely to be ordered for the new frigates.

Since the late 1990s, Singapore's air force has dramatically expanded its capabilities for air defence and for long-range precision strike with the acquisition from the US of F-

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<sup>42</sup> David Boey, 'ST Elec in project to hone soldiers' hitting power', *Business Times* (Singapore), February 26, 2002.

<sup>43</sup> Denesh Divvanathan, 'ST Engg plans foray into China, South America', *Straits Times*, March 9, 2002.

<sup>44</sup> 'RSAF turns to Israel for EW', *Jane's Defence Weekly*, October 10, 1992, p. 5.

<sup>45</sup> 'Navy buys Barak anti-missile system', *Straits Times*, April 23, 1996.

16C/D combat aircraft. By July 2001, no fewer than 62 of these aircraft had been ordered, Eighteen are already in service in Singapore, while others are based in the US for training on a long-term basis. Singapore's Chief of Defence Force did not exaggerate when, in 1998, he claimed that procurement of these aircraft marked a 'quantum leap' in the Singapore's air capability.<sup>46</sup> They are armed with AIM-7M air-to-air missiles, providing a beyond-visual-range engagement capability against hostile aircraft for the first time, and possibly Israeli Python 4 missiles. Although the US government has allowed Singapore to purchase the AIM-120C advanced medium-range air-to-air missile (AMRAAM) for its F-16s, Washington requires - in order to help prevent a regional arms race - that they are stored in the US and will only be delivered to Singapore in a crisis.<sup>47</sup>

In the strike role, the F-16C/Ds can - like earlier RSAF combat aircraft - carry Maverick air-to-ground missiles (both the AGM-65E, and the TV-guided AGM-65B for anti-ship strike), cluster bombs and Paveway laser-guided bombs.<sup>48</sup> However, the new F-16s were also equipped with Sharpshooter navigation and targeting pods, enabling them to execute long-range precision strike missions and to 'self-designate' targets during day or night and in all weather conditions. Singapore's F-16Ds are reported to have received special modifications on the production line, involving the installation of Israeli-supplied electronic countermeasures equipment. This may indicate that these two-seat aircraft are specially equipped for missions to suppress enemy air defences.<sup>49</sup>

The RSAF's older fast combat aircraft - the locally-upgraded F-5S in the air defence role and the A-4SU for strike - are approaching the end of their service life, and from 2006-7 will be replaced by a new multi-role combat aircraft, of which up to 40-50 may be purchased eventually. A competition is presently underway to choose the new aircraft type, with the enhanced capability F-16C/D Block 60, the Eurofighter Typhoon and the French-produced Rafale seen as favorites. This procurement program, which will involve substantial local industrial participation, is likely to lead to further substantial enhancement of the Singapore air force's air defense and long-range strike capabilities. For example, BAE Systems - which is marketing the Eurofighter - is offering Singapore an integrated package of systems virtually identical to those which are being purchased by the UK's Royal Air Force, including the Meteor beyond-visual-range air-to-air missile, ASRAAM (advanced short-range air-to-air missile), together with Brimstone and Storm Shadow short-range attack and long-range cruise missiles.<sup>50</sup>

The army relies less than the SAF's other two branches on advanced technology solutions. Nevertheless, MINDEF has focussed considerable efforts on improving land forces' mobility and firepower, particularly over the last decade. The most obvious accretion of firepower has come from the expansion of the 155mm artillery inventory, particularly with the locally-developed FH-88 and FH-2000 guns, more than 100 of which were in service by the late 1990s. Future artillery equipment will include self-

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<sup>46</sup> Speech by Lt-Gen Bey Soo Khiang, Fort Worth, Texas, MINDEF Internet Webservice, April 9, 1998.

<sup>47</sup> 'Singapore advances fighter procurement', *Jane's Defence Weekly*, March 6, 2002, p. 14.

<sup>48</sup> 'F-16C/Ds boost RSAF's fighting capability', MINDEF Internet Webservice, August 14, 1998.

<sup>49</sup> 'Singaporean F-16D Block 52s reveal Israeli design heritage', *Flight International*, April 22, 1998.

<sup>50</sup> John Fricker, 'Singapore closest to finalizing future fighter preference', *Aviation Week ShowNews online*, <http://www.awgnet.com/shownews/02asia1/airfrm08.htm>

propelled 155mm guns and possibly also multiple rocket launch systems. Anti-armour capabilities have benefited from the infantry's adoption in 1990 of the two km-range Milan anti-tank missile, and since the late 1990s the four km-range Israeli Rafael NT-S Spike, a weapon described as a 'computer with a warhead' and which MINDEF claims is effective even against explosive reactive armor.<sup>51</sup> Since the early 1990s, the air force has flown Fennec helicopters armed with TOW-2A missiles in the anti-armor role. From mid-2002, this helicopter anti-armor capability will be upgraded dramatically with delivery of AH-64D Apaches equipped with highly sophisticated Longbow fire control radars, allowing them to designate their own targets for attack with the latest 'fire and forget' version of the Hellfire laser-guided anti-tank missile.<sup>52</sup>

#### **C4 and ISR capabilities**

Singapore's C4 and ISR capabilities are sophisticated and highly integrated, and increasingly provide the means for the effective operational coordination of the SAF's growing firepower. In 1991, MINDEF requested proposals for a Singapore-wide command, control, communications and intelligence network, based on microwave and fibre-optic channels and including links to air and maritime surveillance assets.<sup>53</sup> During the early 1990s, a branch of DSTA developed such a network, which is focussed on an underground Armed Forces Command Post.<sup>54</sup> According to MINDEF, a 'computerised command and control system provides up-to-the-minute updates of the battlefield situation, including the disposition of friendly and hostile forces'.<sup>55</sup> The Air Force Systems Brigade provides a full picture of the air situation, integrating data from ground-based radars and airborne early warning and control aircraft, and is 'charged with the 'operational and tactical control of all airborne aircraft'.<sup>56</sup> The navy's Coastal Command contributes a central sea surveillance facility, using data from shore-based military and civilian radars, ships at sea, maritime patrol aircraft and shore-based electronic and signals intelligence.<sup>57</sup>

MINDEF has invested heavily in cutting-edge IT for command and control purposes. As early as 1990, Brigadier-General Lee Hsien Loong, then second defence minister (services), claimed that IT could potentially provide the SAF with a 'strategic edge' over an opponent. IT applications which he foresaw included computer-based tools and staff aids to assist SAF commanders and staff officers in operational planning and decision-making.<sup>58</sup> COTS computer technology has been widely exploited: for example, Minister for Defence Tony Tan claimed in 1996 that Singapore was 'among the leaders in the world in using [COTS] computers in real-time command and control systems', notably in integrating air defense sensors and weapons systems for the air force's Air Defence

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<sup>51</sup> 'Tank busters', *Pioneer*, October 1993, pp. 1-4; 'Fact Sheet - Spike anti-tank guided missile [ATGM]', MINDEF Internet Webservice, July 13, 1999.

<sup>52</sup> Andrew Doyle, 'Sharper focus', *Flight International*, February 19, 2002, p. 60.

<sup>53</sup> *Asian Defence Journal*, May 1991, p. 76.

<sup>54</sup> David Boey, 'Defending Singapore: a fragile city-state's approach to defence and security', MA dissertation, University of Hull, 1996, p. 48.

<sup>55</sup> *Defence of Singapore 1994-95* (Singapore: Ministry of Defence, 1994), p. 60.

<sup>56</sup> 'Enhanced national air defence capability', MINDEF Internet Webservice, July 13, 1998.

<sup>57</sup> David Boey, 'Singapore's fleet gets boost from Navy 2000', *International Defense Review*, 12/1995, pp. 67-8; 'Regional maritime air power evolves', *Asia-Pacific Defence Reporter*, February-March 1999, p. 19.

<sup>58</sup> 'SAF to widen use of info technology', *Straits Times*, January 20, 1990.

Systems Division.<sup>59</sup> And, in the intelligence sphere, MINDEF's Joint Intelligence Directorate collaborated closely during the 1990s with the Computer Systems Organisation (now part of DSTA) to develop INSIGHT, a system enabling 'efficient and effective means of information gathering, processing, retrieval as well as timely dissemination' in support of SAF operations.<sup>60</sup>

New technology is also impacting on tactical command and control. In the late 1990s the army introduced the battalion-level Artillery Tactical Command and Control System (ATCCS) to compute and manage firing data more accurately and rapidly. In May 2001, Chief of Navy Rear-Admiral Lui Tuck Yew spoke of the 'quantum improvement of our C4I networks', which combined with the use of muzzle velocity radars for improving gun-firing accuracy had - he claimed - allowed the navy 'to move into the new domain of network warfare relying on precision strike and tactical force dominance'.<sup>61</sup> Naval vessels have incorporated increasingly sophisticated combat information centres, with important elements developed by ST Electronics. The modified Lafayette-class frigates, due to enter service from 2005, will be equipped with a C4I suite integrating ship management, weapons control and communications developed by ST Electronics and navy under the Intelligent Naval Defence Platform 21 program.<sup>62</sup>

One important dimension to Singapore's emerging C4 and ISR capabilities is MINDEF's use of satellites for both communications and surveillance purposes. The republic's first communications satellite was a joint project between Singapore Telecom (SingTel) and Taiwan's Chungwa Telecom, and was launched from French Guiana in August 1998. This satellite, ST-1, was built by the Anglo-French Matra-Marconi company and is designed for both broadcasting and telecommunications (including data, telephony and multimedia) purposes, with its thirty transponders shared equally between Singapore and Taiwan. Its 'footprint' covers 'the whole of Asia'.<sup>63</sup> SingTel has been keen since the late 1990s to increase its satellite access and in January 2001 announced that it would lease 15 transponders on Apstar V, a Chinese-owned but US-built satellite due for launch in February 2003.<sup>64</sup>

Another satellite program began in 1995 when NTU signed an agreement with the UK's University of Surrey covering collaborative research and training in satellite engineering, communications satellites and low earth orbit technology. As a result, in April 1999 a jointly-designed 350-kg mini-satellite was launched from a Russian space base in Kazakhstan and has subsequently passed over Singapore every 90 minutes.<sup>65</sup> It carries NTU-designed components in a package referred to as the Merlion Communications Payload, which has been used to research 'real-time mobile communications and satellite

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<sup>59</sup> Speech by Dr Tony Tan Keng Yam, MINDEF Internet Webservice, October 4, 1996.

<sup>60</sup> Speech by Dr Tony Tan, MINDEF Internet Webservice, November 3, 1997.

<sup>61</sup> Speech by Chief of Navy RADM Lui Tuck Yew at the Naval Platform Technology Seminar 2001, MINDEF Internet Webservice, May 10, 2001.

<sup>62</sup> 'Naval shipbuilding programmes Asia and the Middle East', *Naval Forces*, 1/2000, p. 48; 'Singapore orders La Fayette frigates', *Asia-Pacific Defence Reporter*, April-May 2000, p. 39.

<sup>63</sup> 'Singapore's first satellite to launch in May', *Singapore Bulletin*, March 1998, p. 17; 'Singapore's first satellite blasts off into space', *Straits Times Weekly Edition*, August 29, 1998, p. 24.

<sup>64</sup> 'China to launch APSTAR V in 2003', Xinhua news agency, January 8, 2001.

<sup>65</sup> 'NTU launches first satellite successfully', *Straits Times*, April 22, 1999.

linking of vehicles in GPS-based fleet tracking/control'.<sup>66</sup> The next phase will involve X-SAT, a 100-kg micro-satellite designed and built at NTU in partnership with DSO and scheduled for launch by 2007. This will be the first of a planned 'equatorial belt' of Singaporean micro-satellites, ultimately providing Singapore (and potentially other users located close to the equator) with round-the-clock access to clearer and faster satellite communications.<sup>67</sup> DSO's involvement underlines the project's military significance.

Satellites increasingly play an important role in intelligence collection. Since 1995, the Centre for Remote Imaging, Sensing and Processing (CRISP) at NUS has routinely downloaded images from European, French and Canadian satellites, including the French Spot-4, launched in March 1998.<sup>68</sup> CRISP's role in monitoring marine pollution and forest fires in the region has received wide publicity, but its defence intelligence role has not been acknowledged officially. However, the 10-metre resolution of these images is sufficient to generate militarily useful information on the location of ships, armoured vehicles and aircraft.

Eventually, Singapore may rely to a large extent on its own satellites for the collection of intelligence imagery. The NTU-University of Surrey mini-satellite carries 10-metre resolution cameras, which were reportedly returning 'spectacular' imagery within weeks of launch, and X-SAT will have a remote-sensing as well as a communications role. However, a joint project with Israel (which has reportedly already provided satellite imagery on a commercial basis) may eventually provide Singapore with a greatly-enhanced space-based surveillance capability. Under an agreement signed in June 2000, Singapore will reportedly fund further development of Israel's Ofeq series of satellites, advanced versions of which will eventually be operated by MINDEF.<sup>69</sup>

A key aspect of Singapore's effective information dominance over its region is its ability to collect signals intelligence (SIGINT) through systems land-based systems operated by army signals battalions, as well as other systems are deployed on aircraft and naval vessels. SingTel's radio receiving station at Yio Chu Kang probably also contributes data to the overall SIGINT picture.<sup>70</sup> According to Australian defense analyst Desmond Ball:

Some of Singapore's SIGINT capabilities, especially the systems acquired from Israel over the last decade but increasingly also some designed and developed indigenously by [DTG] and Singapore Technologies, are among the most advanced in the world. Overall, it amounts to a sophisticated capability which provides Singapore with strategic COMINT concerning its neighbours (Malaysia and Indonesia); HF DF/ocean surveillance information, including a very detailed picture of the maritime traffic in the Straits and waters surrounding Singapore; a comprehensive picture of the electronic order of battle (EOB) of its neighbours; and the most advanced electronic

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<sup>66</sup> *Jane's Space Directory 2001-2002* (Coulson, Surrey: Jane's Information Group, 2001), p. 71.

<sup>67</sup> 'Plans for home-made micro-satellites', *Straits Times Weekly Edition*, April 11, 1998; Paula McCoy, 'Work on first made-in-Singapore satellite to begin', *Straits Times*, December 12, 2001.

<sup>68</sup> 'Crisp pictures from S'pore's eye in the sky', *Straits Times*, May 15, 1997; 'New eye in the sky for close look at region', *ibid.*, March 25, 1998.

<sup>69</sup> 'Israel, Singapore to sign satellite deal', *Jane's Defence Weekly*, July 5, 2000, p. 2.

<sup>70</sup> Desmond Ball, 'Signals intelligence (SIGINT) in Singapore', unpublished paper, 1995, pp. 19-25.

warfare (EW) capability in Southeast Asia.<sup>71</sup>

The air force's E-2C Hawkeye airborne early warning (AEW) and control aircraft also contribute significantly to Singapore's intelligence picture and ability to manage the air and sea battle, and provide over-the-horizon targeting for the navy's Harpoon long-range anti-ship missiles. Though the E-2Cs have been upgraded locally with a new mission control system,<sup>72</sup> MINDEF is considering how to maintain and enhance its airborne battle management capability in the future. While the most obvious solution would be to procure a radar-equipped small airliner or regional jet (such as the Boeing 737 with Northrop Grumman's MESA radar, as purchased by Australia), some in DSTA and ST Engg have proposed adopting a distributed network employing the LALEE UAV as a platform performing a range of C4 and ISR functions.<sup>73</sup> Though evidently still at an early developmental stage, LALEE might ultimately carry not only AEW radar, but also sensors akin to those used for battlefield monitoring and stand-off radar reconnaissance by the US Joint Surveillance Target Attack Radar System.

### **Integrated logistic support and maintenance**

One of Singapore's great advantages in developing RMA-type capabilities is the SAF's access to integrated logistic support and maintenance, which are largely missing elsewhere in Southeast Asia. Crucially, the philosophy of Life Cycle Maintenance (LCM) guides the procurement process, with the intention of ensuring the reliability and maintainability of the SAF's equipment, reducing logistic support requirements and facilitating more effective use of the procurement budget.<sup>74</sup> DSTA's target is that LCM costs should be no more than 60% of the initial purchase costs of any particular procurement program.

The central role of local industry (essentially ST companies) in providing logistic support for the SAF has increased substantially over last decade, particularly as a result of the commercialisation of non-combat support services, such as the army's General Supply Base and Ordnance Supply Base, depot-level air force maintenance, and parts of Naval Logistics Command. Comprehensive logistic and maintenance support from the state-controlled local industry is integral to the SAF's potential for sustained RMA-type operations and provides a key strategic advantage over other regional states.

### **ORGANISATIONAL AND DOCTRINAL ISSUES**

It is clear that, in purely technological terms, Singapore is acquiring many of the necessary prerequisites for participation in the RMA. However, the extent to which MINDEF and the SAF are implementing the doctrinal and organisational innovations necessary to absorb these technologies into an effective 'system of systems' remains open to question.

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<sup>71</sup> Ibid., p. 30.

<sup>72</sup> 'Eyes and ears of air force upgraded', *Straits Times*, April 24, 2001.

<sup>73</sup> David Boey, 'Development of LALEE drone started 3 years ago, says Mindef's Chief Scientist', *Business Times* (Singapore), May 11, 2001; David Boey, 'Singapore's new drones make public debut', *ibid.*, February 26, 2002.

<sup>74</sup> 'Applying Life Cycle Management', *Pioneer*, December 1991, p. 35.

Even before discussion of the RMA became vogueish, SAF 2000, a planning blueprint adopted in 1988 as the result of a major force structure review, brought significant changes to organisation and doctrine, particularly in the army. Under Army 2000, a single-service derivative of SAF 2000, army doctrine stressed offensive combined arms operations and the conduct of a '24-hour battle'. In organisational terms, the most important change under Army 2000 was the introduction of genuine (as opposed to nominal) combined arms divisions, each including an armored brigade as well as two infantry brigades, even in peacetime. Another innovation was the establishment of a light rapid deployment division trained for air-mobile and amphibious operations. In the mid-1990s, the organisational evolution went a step further with the integration of reservist and active units within the three combined arms divisions.<sup>75</sup>

SAF 2000 also brought much greater emphasis on joint-service cooperation, and established the Integrated Warfare concept as the basis for a doctrinal framework which attempted to integrate and exploit synergies in the three services' capabilities. Because of the SAF's relative youth, small regular cadre and the lack of strong single-service traditions, institutional obstacles to joint operations are considerably less than in the case of longer-established national armed forces. As a result of this new emphasis on joint-service operations, in 1989 the air force established a Tactical Support Wing, which became Tactical Air Support Command (TASC) in 1991 with responsibility for planning, coordinating and providing air support for the army and navy. One key TASC activity is operating UAVs in support of the army. The increasing emphasis on joint-service cooperation was also clear in the establishment in 1995 of a tri-service officer training academy, the SAFTI Military Institute. In addition, the Tri-Service Staff Course, which is conducted six times a year for a total of up to 240 officers, is aimed specifically at furthering the SAF's Integrated Warfare capability.<sup>76</sup> Joint-service exercises have been held routinely since the 1990s.

MINDEF's commitment to exploiting new information and communications technologies to give the SAF a 'strategic edge' in the area of C4I was clear even in the late 1980s and early 1990s.<sup>77</sup> In 1992, it was reported that the SAF planned operations based on a 'radio electronic combat' doctrine that integrated electronic warfare with reconnaissance, physical disruption and deception.<sup>78</sup> However, this doctrinal emphasis increased greatly under Army 21, the planning blueprint which has guided the development of the SAF's land component since April 1999. Army 21 was written in the context of the RMA and emphasises the development of information capabilities, deriving from the 'integration of command, control, communications and sensor systems', sufficient to achieve 'dominant battle-field awareness'.<sup>79</sup>

Senior MINDEF officials (from the defense minister downwards) and ranking SAF

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<sup>75</sup> For details see Huxley, pp. 123-6.

<sup>76</sup> 'Officers from the army, navy and air force to train together', *Straits Times*, October 7, 1998.

<sup>77</sup> 'Information technology. Giving the SAF a strategic edge', *Pioneer*, March 1990, pp. 14-17.

<sup>78</sup> Prasun K. Sengupta, 'Singapore and the Army 2000 plan', *Military Technology*, 7/1992, p. 73.

<sup>79</sup> 'Building the 21<sup>st</sup> century warrior - Army 21', *Pioneer*, May 1999, p. 13; *Defending Singapore in the 21<sup>st</sup> century*, p. 30.



commanders speak the language of the RMA with a high degree of fluency, and evidently recognise the military component of a broader problem with which Singapore's leaders have been grappling since the 1990s: how to encourage Singaporeans to be more creative in order to retain and enhance the city-state's competitive advantages. A key problem in relation to the RMA is that Singapore's military command and control have in the past tended to be rigid and strictly hierarchical, with effective authority concentrated at the higher levels of MINDEF and the SAF. A reluctance to delegate authority to middle-level and junior commanders has been characteristic. For example, air force squadron commanders have hitherto been able to exercise little operational initiative compared with their Australian or British counterparts. The SAF's lack of organisational flexibility has been reinforced by not only the political and administrative system, which has tended not to reward individualism or creativity, but also by the local cultural milieu in which respect for elders and seniors, and considerations of 'face', have traditionally been central features.

As in other areas of competition it is evident that, in the field of defense, technological superiority alone is not sufficient for Singapore to come out on top. New information and communications technology has evidently stimulated much thinking within the SAF about the need for new command and control doctrines and new forms of military organisation. In 1999 the Singapore air force's Chief of Staff, Brigadier-General 'Rocky' Lim, pointed out that, by providing rapid access to more information, the latest IT applications increase the pressure for decision-making at lower levels in the chain of command. According to Lim, this 'could change your entire doctrine of air warfare'.<sup>80</sup> The influence of intensified interaction with Western armed forces, which already practice more decentralised command and control, may also push MINDEF and the SAF to delegate operational authority to lower levels of command more effectively. This applies most obviously in case of the air force's long-term training programmes in the United States, Australia and France), but all three services benefit from extensive interaction with Western forces that are themselves going through fundamental doctrinal and organisational change.

However, glimpses of internal debates within the armed forces which are revealed in sources such as *Pointer* (the official SAF journal aimed at commissioned officers) suggest some impatience amongst younger middle-ranking officers for doctrinal and organisational change which would lend greater substance to Singapore's incipient RMA. As early as 1992, one young army officer (the commander of a semi-elite army Guards battalion) argued that the SAF could gain an edge over opponents by adopting the German military philosophy of *Auftragstaktik*, involving considerable decentralisation of command and control, and greater expectations of initiative on the part of lower-level commanders and even individual soldiers:

Our Asian heritage has unfortunately...put too much premium on the value of 'face'. We are exceedingly hierarchy-conscious to the extent that constructive criticism is extremely rare from bottom-up. It will take much time and deliberate effort to dispel the fear of ... subordinates to speak up if they think

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<sup>80</sup> 'Millennium force', *Flight International*, June 16, 1999, p. 67.

their superiors are in the wrong, and for the latter to accept constructive criticism.<sup>81</sup>

Writing almost a decade later, a more senior SAF staff officer returned to this theme, pointing to both the German army's *Auftragstaktik* and the Israeli army's similarly decentralised command system, both based heavily on the initiative of commanders and soldiers, as examples to be followed in implementing Army 21.<sup>82</sup>

More recently, several *Pointer* articles have argued for major organisational change within the SAF in response to technological developments. The essence of these arguments is that the SAF should adopt what one officer termed a 'flatter and more network-based system'.<sup>83</sup> More specifically, another officer has indicated that Army 21 may just 'put new wine into old bottles', and argues in favour of 'streamlined and flattened military organizations' which will 'allow the SAF to compress the time needed for battle-procedure and decision-making' while at the same time reducing the vulnerability of the army to a pre-emptive enemy attack. Following the examples of the US Army's Force XXI and the French brigade-based army, he proposes that the Singapore army's basic combined arms units should be organized around brigades rather than divisions.<sup>84</sup>

## **SINGAPORE'S STRATEGIC FUTURE: HOW RELEVANT IS THE RMA?**

The great challenge for MINDEF and the SAF in the future will be to exploit advanced technologies in ways which are relevant to their requirements in light of the city-state's changing strategic circumstances, while simultaneously developing appropriate and effective military doctrines and organisational forms. Singapore's regional security environment has deteriorated significantly since the economic recession of 1997-98 and there are few signs that the city-state's strategic circumstances will improve in the foreseeable future. Relations with Malaysia remain unstable and unpredictable, being driven in large part by economic, social and political developments there that are outside Singapore's control. War between Singapore and Malaysia still remains a remote possibility, but its prospect has entered the politicians' and media commentators' discourse on bilateral relations during early 2002.

Malaysian defence procurement plans mimic the SAF's efforts to develop RMA-style capabilities. The Malaysian armed forces' potential acquisition over the next decade of advanced weapons such as multiple-launch rocket systems, long-range anti-tank missiles, airborne laser target designators, and medium-range air defence missiles, on top of the new air force and naval equipment already purchased since the late 1990s, suggest that maintaining the SAF's precious technological edge may become an increasingly

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<sup>81</sup> Major Peter Gwee Chon Lin, 'Auftragstaktik. A philosophy for management, training and war', *Pointer*, vol. 18, no. 4 (October-December 1992), p. 34.

<sup>82</sup> Lieutenant-Colonel Tan Kim Seng, 'Initiative as the fighting power in the Army 21's vision' [sic], *Pointer*, vol. 27, no. 3 (July-September 2001).

<sup>83</sup> Major Seet Pi Shen, 'The revolution in military affairs (RMA): challenge to existing military paradigms and its impact on the Singapore Armed Forces', *Pointer*, vol. 27, no. 2 (April-June 2001), p. 16.

<sup>84</sup> Captain Fong Kum Kuen, 'A quantum leap towards knowledge warfare: revolution in military organizations in the SAF', *Pointer*, vol. 27, no. 2 (April-June 2001), pp. 80, 92, 94.

expensive business. However, taking into account Malaysia's educational and technological shortcomings, the lack of coherence in its procurement strategy, and Singapore's far superior defense-industrial and R&D capabilities, there seems little doubt that the SAF will be able to retain the upper hand for the foreseeable future.

In these uncertain circumstances, Singapore's leaders - while never pointing at any specific threats - have repeatedly emphasised the continuing importance of the republic's military instrument as a deterrent. The ability of Singapore's defense establishment to continue developing and integrating the advanced information and communications technologies extensively employed for command and control with satellite and other surveillance systems (including airborne early warning, maritime patrol and tactical reconnaissance aircraft, UAVs, and ground-based radars), and with precision-guided weapons, will be key to the SAF's continuing regional military superiority. The aim will be to allow the SAF (particularly the air force, navy and artillery) to locate, target and destroy targets more effectively in the context of round-the-clock combined arms and joint-service operations. At the same time, greater emphasis on criteria of range and endurance in selecting major platforms (principally ships, submarines and aircraft) will provide Singapore with an artificial form of strategic depth by allowing the SAF to fight at greater distance from home.

However, like their counterparts in other states attempting to engage in the RMA, Singapore's security planners have needed to consider possible asymmetric counters to their probable conventional military superiority. Social and political developments in Indonesia pose a new type of security concern for Singapore. Continuing social, economic and political instability, together with intensifying secessionist and inter-communal conflict around Indonesia's periphery, have raised the possibility of a 'complex emergency' on Singapore's doorstep involving a breakdown in law and order, warlordism, communal conflict, piracy, hostage-taking, unregulated population movements, famine, rampant disease and environmental catastrophe. Though unlikely, it is conceivable that the SAF could be drawn into diffuse, low-intensity operations around the periphery of Indonesia (in the Riau Islands to Singapore's south, for example) if the situation there deteriorated significantly.

Other new challenges - from either governments or non-governmental groups - might include various combinations of bombings, the use of weapons of mass destruction (particularly chemical or biological agents) or information attacks, aimed primarily at Singapore's civilian population and national infrastructure as well as military targets. Chemical contamination of Singapore's water supply, for example, could be a particular effective asymmetric weapon. Though countering such asymmetric threats would largely be the responsibility of 'Home Team' non-military agencies under the Ministry of Home Affairs (principally the police and civil defense force), MINDEF claims that the SAF has a range of capabilities relevant to such contingencies (for example, the army's Special Operations Force in the anti-terrorist role). According to Deputy Prime Minister and Minister for Defence Tony Tan, during 2000-01 MINDEF and the SAF, working with the 'Home Team', 'made good progress' in developing 'concepts, frameworks and operational

plans' in relation to potential low-intensity conflict.<sup>85</sup>

The September 11 attacks in the US and the Singapore authorities' arrest in December 2001 of 15 members of a terrorist group allegedly linked to *Al-Qaeda* in connection with a plot to attack local targets have accentuated the city-state's concerns over potential asymmetric threats. The main impact on Singapore's security and defence planning was to reinforce the validity of the long-established idea of Total Defence, which involves non-military agencies as well as MINDEF and the SAF in ensuring Singapore's security.<sup>86</sup> In November 2001, the government announced that it would implement a 'homeland security' strategy involving closer cooperation between MINDEF and the home affairs ministry, and the SAF and police.<sup>87</sup> By January 2002, a National Security Secretariat had been set up to oversee this cooperation against 'non-conventional threats and new security challenges', and the government emphasised that it would need to allocate greater resources to the SAF, police and civil defense force to help them counter new threats.<sup>88</sup>

Particularly in light of recent events, it is clear that Singapore's developing RMA-type capabilities do not provide a panacea for its security needs. However, they are not necessarily irrelevant to low-intensity concerns. For example, the greatly-improved ISR capabilities likely to be generated by Singapore's investment in UAVs and satellites will be highly relevant to the monitoring of population and shipping movements to the south. Moreover, technological improvements in the capability of ordinary infantry soldiers, ranging from the SAR-21 rifle to the Future Soldier System, have a wider utility than simply on a high-intensity battlefield against a conventional enemy. Information security systems may be as useful in protecting 'critical national infrastructure' (such as public utilities and air traffic control) against 'cyber-terrorism' as they are in defending military C4I systems against attacks by opposing armed forces.

## CONCLUSION

Singapore's resources for defense R&D and even for military procurement are slim compared with those available to the major Western military powers. To put Singapore's defense budget in perspective: in 2001/2, in approximate terms it amounts to less than 2% of the United States', 10% of Japan's, or 25% of Taiwan's military spending. Moreover, even the United States' close military allies in Europe, such as the United Kingdom (which spends more than seven times as much as Singapore on defense) face considerable difficulties in keeping up with US technological advances and ensuring inter-operability. Realistically, in relation to the major RMA players, Singapore's incipient advanced technology military capabilities might best be described as 'RMA lite'.<sup>89</sup> However, Singapore is not expanding the SAF's technological capacity primarily with a view to participating in US-led coalition warfare. Interconnectivity with US forces may be a

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<sup>85</sup> Statement by Dr Tony Tan at the Committee of Supply debate, March 8, 2001, Singapore Government Press Release, March 8, 2001.

<sup>86</sup> 'Sept 11 proves need for Total Defence, says DPM Tan', *Straits Times*, October 27, 2001.

<sup>87</sup> Lydia Lim, 'S'pore to have "homeland security"', *Straits Times*, November 5, 2001.

<sup>88</sup> Lydia Lim, 'National security secretariat set up at Mindef', *Straits Times*, January 7, 2002; Dr Tony Tan, Ministry of Defence Addendum to the President's Address, Ministry of Defence Press Release, March 31, 2002.

<sup>89</sup> I am indebted to Malcolm Davis for this term.

welcome spin-off, but MINDEF's principal aim is to develop forces that in the last resort can defend Singapore against regional threats autonomously.

For less than US\$5bn annually, MINDEF and the SAF provide Singapore with a remarkable range of military capabilities. In Singapore's immediate regional context, these capabilities presently far outclass those of any potential opponent in conventional military terms. Singapore possesses highly educated and IT-literate military, research and industrial personnel, and its defence-industrial and R&D establishment has set up an extensive network of international links. For these reasons, it can almost certainly sustain its conventional military advantage for at least the next decade. Indeed, if Singapore develops military doctrine and organisation which allow the SAF to exploit its C4, ISR and firepower to the full, it may be able to assure continued military superiority in Southeast Asia even if potential regional adversaries (notably Malaysia) are eventually able to catch up in technological terms.